Intelligence and Working Memory as Predictors of Learning Outcomes in School-Aged Children

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Master’s Thesis in Psychology

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Subject: Psychology	
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Abstract: Several factors, both cognitive and non-cognitive are associated with pupils' academic performance. Regarding cognitive factors, intelligence and working memory play important parts, however, findings on whether intelligence or working memory is more important for learning outcomes are mixed. The present study investigated the predictive power of intelligence and working memory on learning outcomes in a population of Swedish-speaking Finnish school-aged children. The sample in the present study consisted of 109 children in the age range 7:11–16:4 years, gathered with a stratified sampling procedure. Teacher-assigned school grades of the participants in six major subjects (Swedish, Finnish, English, mathematics, biology, and history) were collected via the participants' parents. Furthermore, the participants were assessed with the Swedish version of the WISC-V. In the present study, learning outcomes were measured with a grade point average of the teacher-assigned school grades. Intelligence and working memory were measured with the General Ability Index, and the Working Memory Index from the WISC-V, respectively. The predictor variables were first entered in the linear regression analyses in one order and then in the reverse order to examine their mutual variance. The results of the present study indicate that intelligence has a stronger predictive power on school grades than working memory has. This was the case for the whole sample, as well as for the younger and older participants (children in grade 2–5 and 6–9, respectively). Intelligence and working memory together accounted for one fourth of the variance in school grades, which indicates that there are several other factors to consider.	
Keywords: Intelligence, working memory, learning outcomes, school-aged children	
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Abstrakt: Flera faktorer, både kognitiva och icke-kognitiva, är förknippade med elevers akademiska prestationer. När det gäller kognitiva faktorer spelar intelligens och arbetsminne viktiga roller. Forskningsresultat om huruvida intelligens eller arbetsminne är viktigare för skolresultat pekar i olika riktningar. Den aktuella studien undersökte den prediktiva styrkan hos intelligens och arbetsminne för skolresultat hos finlandssvenska barn i skolåldern. Samplet i denna studie bestod av 109 barn i åldersintervallet 7:11–16:4 år och samlades in genom stratifierat urval. Deltagarnas skolvitsord i sex ämnen (modersmål, finska, engelska, matematik, biologi och historia) samlades in med hjälp av deras föräldrar. Därtill utreddes deltagarna med den svenska versionen av WISC-V. I föreliggande studie mättes skolresultat med ett medeltal av deltagarnas skolvitsord. Intelligens och arbetsminne mättes med det kognitiva resursindexet respektive arbetsminnesindexet ur WISC-V. Prediktorvariablerna matades först in i regressionsanalysen i en ordning och sedan i omvänd ordning för att undersöka hur stor del av variansen som respektive prediktor tillför. Resultaten indikerar att intelligens har en starkare prediktiv styrka på skolresultat jämfört med arbetsminne. Detta var fallet för såväl hela samplet, liksom för de yngre och äldre deltagarna skilt (barn i årskurs 2–5 respektive 6–9). Intelligens och arbetsminne stod tillsammans för en fjärdedel av variansen i skolresultaten, vilket tyder på att det också finns flera andra faktorer att ta hänsyn till.	
Nyckelord: Intelligens, arbetsminne, skolresultat, skolelever	
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Table of Contents

Introduction

There is great variation in pupils' academic performance and several factors, both cognitive and non-cognitive, are associated with this variation (Chiesi & Primi, 2010). Regarding cognitive factors, intelligence (here referred to as IQ) and working memory (WM) play important parts. The question is whether IQ or WM is more important for learning outcomes. Research findings on this topic are mixed. Some studies indicate that WM, as opposed to IQ, has greater predictive power on learning outcomes (Alloway & Alloway, 2010; Siquara et al., 2018), while other studies have found the opposite (Giofrè et al., 2017). The aim of the present study was to investigate the predictive power of IQ and WM on learning outcomes in a population of Swedish-speaking Finnish school-aged children.

Learning Outcomes, Intelligence, and Working Memory

Learning Outcomes

Learning outcomes can be measured in several different ways, e.g., with exams, school grades, and achievement tests. In the present study, learning outcomes were measured with school grades given by the children's teachers.

The assessment of a pupil's learning process has two aims that support each other. The first aim is to supervise and encourage the pupil in their studies and to develop the pupil's ability for self-assessment. The second aim is to define the extent to which the pupil has achieved the learning goals set for the subjects (The Finnish National Agency for Education, 2020a). School grades are given by the teacher (or teachers) who has taught the pupil. The Finnish National Agency for Education provides guidelines for grading of school performance in Finland. Pupils in grades 1–3 are given either a verbal or numeric grading in accordance with the local educational organiser. Pupils in grades 4–9 are in general given numeric grading. However, verbal grading can be given as a complement for the children in grades 4–9. The numeric grading scale ranges from 4 to 10, where 5 is the first grade considered as pass. The verbal grading scale, in turn, can consist of a different number of levels depending on the educational organiser. The scale can, for example, consist of five levels (fail, sufficient, satisfactory, good, excellent) or four levels (fail, satisfactory, good, excellent). If a verbal grading is given, it should always be clear whether the performance is considered pass or fail (The Finnish National Agency for Education, 2020a).

Intelligence

The American Psychological Association (n.d.) defines intelligence as "the ability to derive information, learn from experience, adapt to the environment, understand, and correctly utilize thought and reason". The intelligence quotient (IQ) is a standard measure of an individual's intelligence level based on an individually administered psychological test. The test consists of tasks that for instance tap the ability to solve problems and form concepts (Wechsler, 2014a). Historically, the first IQ test was created to predict school performance in order to determine the most suitable school setting for a child, as summarized by Giofrè et al. (2017). Currently, there is a range of tests that aim to measure IQ. Of these, the Wechsler scales are among the most frequently used (Gibbons & Warne, 2019). The most recent version for school-aged children is the Wechsler Intelligence Scale for Children - Fifth Edition (WISC-V), which was used in the present study.

It has been suggested that IQ is a key factor that underlies the relationship between WM and learning (Nation et al., 1999; Stothard & Hulme, 1992). However, there is also evidence suggesting that WM shares unique links with learning even after statistically controlling for IQ (Cain et al., 2004; Gathercole et al., 2006a). Research points towards a strong correlation between IQ and learning outcomes (Deary et al., 2007; Sternberg et al., 2001). More specifically, performance in verbal IQ tests is a stronger predictor of learning outcomes, compared to performance in nonverbal IQ tests, as cited by Roth et al. (2015). Furthermore, it has been shown that the association between IQ and learning outcomes is stronger when standardised achievement tests are used as an outcome variable instead of school grades (Sternberg et al., 2001). An explanation for this is that motivation may influence school grades, which cover a longer time period, more than academic achievement which is measured at a specific time point (Sternberg et al., 2001).

Working Memory

WM is a system with limited capacity that enables us to process information and store it temporarily (Baddeley, 2000). WM is involved in several complex tasks, such as comprehension, learning, and reasoning (Baddeley & Hitch, 1974). WM evolves from birth through childhood and adolescence and plays a key role in child development (Cowan & Alloway, 2008). WM has been found to be a "bottleneck for learning" and since learning is something that happens gradually, poor WM skills early on might lead to problems with the learning process and academic success later in life (Gathercole et al., 2006a). Problems with WM can lead to several difficulties in the classroom, ranging from difficulties remembering instructions given by the teacher to impaired performance on more complex tasks (Gathercole et al., 2006b). Furthermore, among adults, poor WM has been found to be related to lower self-discipline (Duckworth & Seligman, 2005) and mind wandering (Kane et al., 2007), both of which might affect learning outcomes. Impairments in WM also have a major role in neurodevelopmental disorders, such as ADHD (Willcutt et al., 2005).

WM can be measured reliably in children from four years of age (Alloway et al., 2004), and it gives information about a child's capacity to learn (Alloway et al., 2005; Engel et al., 2008). WM is typically measured with complex span tasks. Such tasks build on the assumption that WM always includes a short-term memory (STM) component (Aben et al., 2012). STM refers to a cognitive system that holds cognitive information, such as digits, words, or names, as well as sensory events and movements, for a brief period of time (Cowan, 2008) and could be seen as the maintenance part of WM (Aben et al., 2012). STM is typically measured with simple span tasks. These tasks require one to hold information, for example numbers or symbols, in one's mind for a short period of time before recalling the information. WM tasks are more challenging than these simple STM tasks because a demanding secondary task is added. The demanding part may, for example, consist of solving a mathematical problem (Unsworth & Engle, 2007) or recalling digits in reverse sequence (Alloway & Alloway, 2010). STM and WM are different theoretical concepts, but there is considerable overlap between them (Aben et al., 2012). However, it has been shown that WM skills (measured by backward digit recall) are more strongly associated with learning outcomes compared to STM skills (measured by forward digit recall) (Daneman & Merikle, 1996).

There is great individual variation in WM performance (Alloway et al., 2006), which has been suggested to have important consequences for the child´s learning process (Cowan & Alloway, 2008). In some cases, WM problems among children are thought of as problems with attention. In other cases, the problems are not detected at all (Gathercole et al., 2006a). Proper detection and early intervention are important to support the child and to reduce the risk of subsequent learning problems. In the classroom, WM load can be reduced in several ways e.g., by the teacher repeating instructions, simplifying complicated assignments, and helping the child create learning and study strategies (Gathercole et al., 2006b).

Learning Outcomes in Relation to Intelligence and Working Memory

Learning Outcomes in Relation to Intelligence

Roth et al. (2015) conducted a meta-analysis on IQ and learning outcomes. The analyses included 240 independent samples with altogether 105,185 participants with the average age of 13.9 years. In the included studies, learning outcomes was measured with grade point average (GPA), or similar means of school grades. These were chosen as the outcome variable since Roth et al. (2015) suggested that school grades have a stronger effect on the child's school and occupational career, compared to for example school achievement tests. IQ was measured with standardised IQ tests or with comparable tests.

The results of the meta-analysis indicated a moderate and significant correlation between IQ and school grades (r = .44). The school subjects included in the primary studies were clustered into subgroups in order to reach a clear overview. The subgroups were e.g. Mathematics and Science (including e.g., mathematics, biology, and physics), Languages (e.g., English, reading, and literature), and Social Sciences (e.g., social studies, history, and geography). Looking into these subgroups, the correlation between IQ and Mathematics and Science, was the highest (r = .42), closely followed by Languages (r = .36), and Social Sciences (r = .35). The researchers concluded that the strength of the correlations clearly demonstrates that IQ has a substantial influence on school grades and that IQ might be the most influential variable in this context. Further, the studies in the meta-analysis included three different types of IQ tests: verbal, nonverbal, and mixed. The mixed tests showed the highest population correlation with school grades (r = .47), followed by the verbal tests (r = .42), and nonverbal tests (r = .37). Roth et al. (2015) suggest that this might be explained by the fact that verbal skills are of great importance, both when it comes to participating during lessons and when writing tests. The results showed slightly higher correlations among children in middle (r = .46) and high school (r = .46), compared to children in elementary school (which is the three first school years, r = .40). They suggest that this could be explained by the fact that it might be easier to compensate for deficits in IQ through practice at lower grades, where the learning material is easier to follow since it is more limited and concrete.

In the test manual of a previous version of the WISC assessment battery, the WISC-III, a correlational study with teacher-assigned school grades, GPA, and the WISC-III indexes were presented (Wechsler, 1992). The included school subjects were mathematics, English, and reading and spelling. The GPA was estimated by the average of the grades in mathematics and English. In total 617 children (aged 6–16 years, median 12 years) participated, and the results showed a moderate correlation between the Full Scale IQ (FSIQ) and GPA (r = .47). The correlation between the Freedom of Distractibility index (FDI) and GPA was slightly weaker (r = .34). The FDI, comprising the Digit Span and Arithmetic subtests, corresponds roughly to the Working Memory Index (WMI) in the WISC-V. Additionally, a correlational study with the WISC-III indexes and results in achievement tests was presented in the manual (Wechsler, 1992). The achievement tests measured mathematics, reading, and written language. A mean of the scores in the achievement tests correlated strongly with the FSIQ (r = .74), and the correlation with the FDI was, as previously, slightly weaker (r = .63).

In sum, the correlations were stronger when achievement tests were used compared to the GPA. This was the case for both the FSIQ and the FDI (Wechsler, 1992). Furthermore, the correlation between IQ and school grades as reported by Roth et al. (2015) yielded almost the same result as the correlation between the FSIQ and the GPA in an earlier study by Wechsler (Wechsler, 1992).

Mathematical and Reading Skills in Relation to Working Memory

Several studies have focused solely on mathematical skills as learning outcomes (Alloway & Passolunghi, 2011; Holmes & Adams, 2006. See Raghubar et al., 2010, for a review on WM and mathematics). It has been found that WM is involved in general mathematical achievement, mental calculations, and geometrical problem-solving (Bull et al., 2008; Caviola et al., 2012; Giofrè et al., 2014). Furthermore, it has been shown that low scores on WM tasks are associated with weak computational skills (Bull & Scerif, 2001) and weak performance on arithmetic tasks (Swanson & Sachse-Lee, 2001). Regarding reading ability, WM has been found to predict achievement in reading (Swanson & Beebe-Frankenberger, 2004) and to be associated with reading comprehension (Borella & de Ribaupierre, 2014).

Learning Outcomes in Relation to Intelligence and Working Memory

The relationship between learning outcomes and the two predictors IQ and WM simultaneously has also been studied. Alloway and Alloway (2010) conducted a longitudinal study to investigate the predictive roles of IQ and WM, respectively STM, on learning outcomes. Learning outcomes was probed with standardised tests of reading, spelling, and math. WM was measured with backward digit recall and listening recall, and STM was measured with digit recall and word recall, at two time points (six years apart). IQ was at time 1 estimated with the Block Design and Object Assembly subtests from WPPSI-R, and at time 2 with the Vocabulary subtest from WISC-III. The results indicated that children's WM skills are a stronger predictor for learning outcomes compared to IQ, even though both WM skills and IQ shared a considerable amount of variance with learning outcomes. In line with these results, Siquara et al. (2018) found that WM showed higher predictive power on learning outcomes compared to IQ. In their study, learning outcomes was assessed with tests of reading, spelling, and arithmetics. IQ was estimated with the subtests Vocabulary and Block Design from WISC-III. WM and STM were estimated with both forward and backward recall tasks of Digit Span in WISC-III, and a similar visual task, the Corsi block-tapping test.

Giofrè et al. (2017) investigated the relationships between IQ, WM as well as academic self-esteem on learning outcomes. Learning outcomes were assessed with tests of mathematics literacy and reading literacy, and academic self-esteem was measured with a self-report scale. IQ was estimated with the Cattell Culture Fair Intelligence Test and Primary Mental Abilities. WM was measured with forward and backward versions of word span and matrices span, and with dual tasks. Their results indicated that learning outcomes depend on both cognitive and non-cognitive factors. Within the cognitive factors, IQ was a stronger predictor than WM for learning outcomes. Within the non-cognitive factors, academic self-esteem was effective at predicting achievement when cognitive measures were controlled for. Furthermore, Caemmerer et al. (2018) studied the effects of cognitive abilities on child and youth learning outcomes. Learning outcomes were assessed with the Weschler Individual Achievement test (WIAT). WIAT consists of tests that aim to measure math problem solving and reading comprehension, among other domains. Cognitive abilities were assessed with WISC-V. The results indicated that the effect of cognitive abilities on all achievement skills was strong, but often overlapped with the effect of fluid reasoning. Furthermore, they found that WM was particularly important for younger children, significantly influencing most of the achievement skills related to learning outcomes. In their study WM was assessed with the WISC-V subtests Digit span, Picture span, and Letter-Number Sequencing. In this study the effect of IQ and WM on learning outcomes was not directly compared to each other.

To summarize, the importance of IQ for learning has been shown in several studies (Deary et al., 2007; Sternberg et al., 2001), and so has the importance of WM (e.g., Engel et al., 2008; Gathercole et al., 2006a). The question is whether IQ or WM has the greatest predictive power on learning outcomes. As for today, there are mixed answers to this question and the previous studies on this topic have measured IQ and WM, as well as learning outcomes in different ways, which add to the dissensus. To date, there seems to be slightly more studies pointing towards WM having greater predictive power on learning outcomes, compared to IQ (Alloway & Alloway, 2010; Siquara et al., 2018). Further research is needed to confirm or disprove this.

Aims of the Study

The aim of the present study was to investigate the predictive power of IQ and WM on learning outcomes in Swedish-speaking Finnish school-aged children. In this study, learning outcomes were measured with teacher-assigned school grades. IQ was measured with the General Ability Index (GAI) and WM with the Working Memory Index (WMI), both from the WISC-V. Previous studies have explored the predictive power of IQ and WM on school grades separately, but to our knowledge comprehensive studies that simultaneously explore the effect of these two predictors on school grades are missing. Therefore, this study fills a gap. Knowledge about these relationships is of clinical importance, for example when combining results from a clinical assessment and information from the classroom and school grades. The results of the present study could be of importance for clinicians when interpreting the results of an assessment and when planning interventions such as possible support in school.

Most studies indicate that WM skills are a stronger predictor for learning outcomes compared to IQ (Alloway & Alloway, 2010; Caemmerer et al., 2018; Siquara et al., 2018), even though results indicating the opposite do exist (Giofrè et al., 2017). Based on these findings it was hypothesized, that WM would have a stronger predictive power on learning outcomes, compared to IQ also in the present study.

Method

The present thesis represents a substudy of the FinSwed Study carried out at the University of Helsinki, which evaluated the performance of Swedish-speaking Finnish children on the Swedish versions of WPPSI-IV, WISC-V, and NEPSY-II.

Participants

The sample in the present study consisted of 109 children. At the time of the first cognitive assessment session, the participants were 7:11–16:4 (M = 12.31, SD = 2.48) years. The participants were either monolingual Swedish-speaking or bilingual Swedish-Finnish-speaking, and all participants attended Swedish-speaking schools in Finland. Sample characteristics are presented in Table 1.

Table 1

Demographics and Background Characteristics of the Participants (N = 109)

Characteristic	*n*	%
Sex		
Girls	59	54.1
Boys	50	45.9
Language		
Monolingual (Swedish)	61	56.0
Bilingual (Swedish and Finnish)	48	44.0
Grade level		
2–3 (age range: 7:11–9:9)	18	16.2
4–5 (age range: 10:0–11:8)	30	27.0
6–7 (age range: 11:11–13:3)	30	27.0
9 (age range: 14:11–16:4)	31	27.9
Regions		
Ostrobothnia	42	38.5
Southwest Finland	17	15.6
The capital region	34	31.2
Coastal areas east and west of the capital region	16	14.7
Maternal education level		
Level 1 [a]	18	16.5
Level 2 [b]	30	27.5
Level 3 [c]	59	54.1
Missing	2	1.8
Paternal education level		
Level 1 [a]	35	32.1
Level 2 [b]	29	26.6
Level 3 [c]	45	41.3

[a] Degree from upper secondary education, vocational education, or lower. [b] University of applied sciences degree, or Bachelor's degree. [c] Master's or doctoral degree.

The current study utilized the sample selection of the FinSwed study depicted in Appendix 1 and described in detail in the next chapter. The parents of the 165 children eligible to participate in the present study were sent an online questionnaire regarding school grades. Out of these, 113 (68.5%) parents answered, but 4 of the answers were too unclear to be taken into account. In total, answers regarding school grades from 109 (66.1%) children were considered.

Attrition data was examined for the GAI and the WMI. An independent samples t-test showed a significant difference in both indexes (see Table 2). The children whose parents completed the questionnaire (participants) outperformed the drop-out group (non-participants). However, in the contingency table analyses (Chi-Square tests) the groups did not differ regarding the number of boys and girls ($\chi2(1) = 1.88$; $p = .170$) as well as mono- and bilinguals ($\chi2(1) = .09$; $p = .770$).

Table 2

Differences Between Children With and Without Information About School Grades

Variable	Participants (n = 109) M (SD)	Non-participants (n = 56) M (SD)	p	d
GAI	107.56 (12.33)	101.48 (11.22)	**.002**	.51
WMI	108.19 (13.52)	102.63 (12.19)	**.011**	.43

Note. GAI = General Ability Index; WMI = Working Memory Index. The category “non-participants” stands for those children whose parents did not return the questionnaire about school grades. Significant p-values are bolded.

Procedure

Sampling procedure. The FinSwed study participants were chosen with a stratified sampling procedure based on the geographical distribution of the Swedish-speaking population in Finland. The sample was collected from four different bilingual regions in Finland. These were Ostrobothnia, Southwest Finland, the capital region, and the coastal areas east and west of the capital region. The participants were selected in relation to the percentage of pupils in Swedish-speaking schools in cities, localities, and in the countryside. The partaking municipalities were chosen so that the mean percentage of the parents’ highest level of education in the chosen municipalities was equivalent to the highest level of education for the larger region. The psychologists participating in the study chose which schools to be included and the schools were chosen based on practical issues. The participants were selected with a randomized sampling method by choosing every fourth girl and boy in alphabetical order, starting from the second name on the list. The following child on the list was chosen in cases where the parents did not give their permission for study participation, or if the child met any of the exclusion criteria.

Exclusion criteria. In the FinSwed study, children diagnosed with a neuropsychiatric, neurological, or psychiatric disorder, or with medication for psychiatric or neurological conditions, were excluded. Likewise, children who received neurological, psychiatric, or phoniatric specialized healthcare were excluded. Additionally, children with a formally diagnosed learning disability or a non-corrected visual or hearing impairment met the exclusion criteria. This was also the case for prematurely born children (prematurity was defined as birth before the 37^{th} week of pregnancy and/or a birth weight of less than 2500g). Lastly, children who recently had been or were to be assessed with a Wechsler test were excluded. The sample selection for the present study is illustrated in Figure 1.

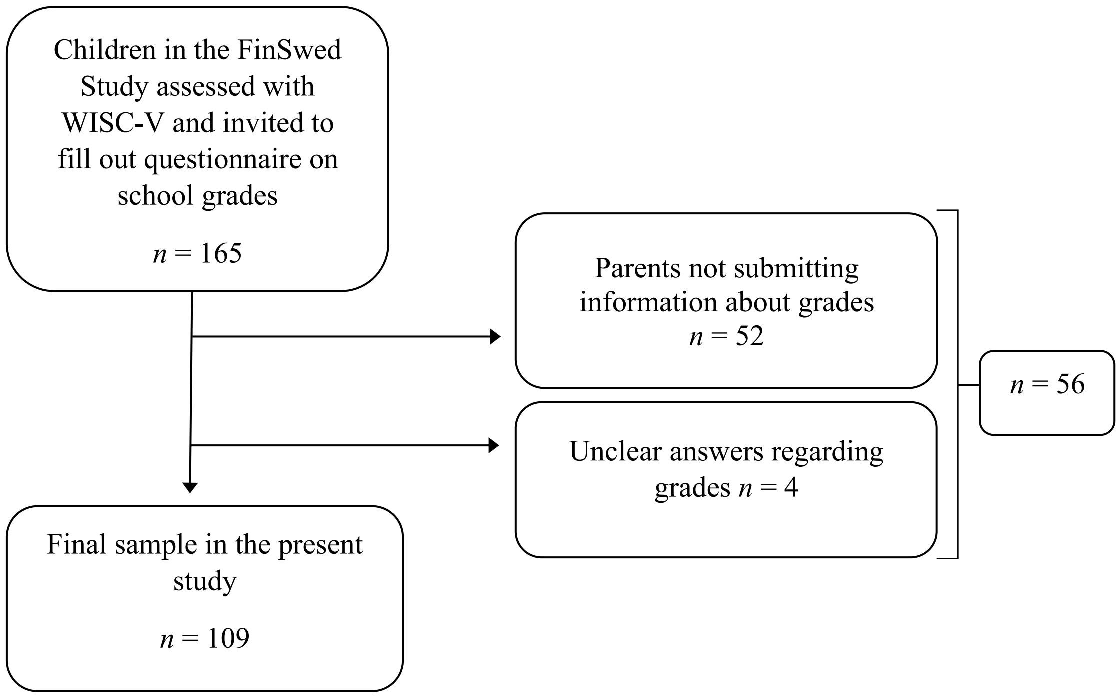
Ethics permission and consents. In June 2019, ethical permission for the FinSwed study was granted by the University of Helsinki Ethical Review Board in the Humanities and Social and Behavioural Sciences. In August 2020, an additional permission was granted to collect further data for the present substudy. Written consent for data collection was obtained from each city and municipality participating in the study and from the principals of the schools. Parents gave a written permission for their child to participate. Children of the age of 15 and older gave written permission themselves, as well.

Data collection. For the initial data collection in the FinSwed study, psychologists and trained research assistants assessed the participants with the Swedish versions of either WPPSI-IV or WISC-V as well as with parts of NEPSY-II. The 109 participating children in the present study were all assessed with WISC-V and parts of NEPSY-II. These assessments took place between October 2019 and February 2021. For this sample the length of each complete assessment (including also assessment with NEPSY-II) was on average 2.85 hours (range 1.83–4.33 hours), most often split into three sessions (range 1–5). These numbers refer to all tests/the whole test battery used in the FinSwed Study, which means that the time for NEPSY-II also is included. Due to the COVID-19 pandemic and its societal restrictions, some assessments (n = 8) were held with a longer interval between the sessions. The intervals in these cases were 2–5 months long. A new test age was counted for the latter sessions in these cases and the relevant subtests were scored according to the new test age.

Data regarding school performance was collected between September 2020 and May 2021. All parents were sent an email with a link to an online questionnaire sited on e-lomake.

Figure 1

Flowchart of the Sample Selection in the Present Study



Measures

Grading of School Performance

Correlation analyses between the different school subjects were conducted. The results revealed a few strong correlations (rs = .58–.79, n = 3), several moderate correlations (rs = .35–.49, n = 10), and a couple of weak correlations (rs = .20–.30, n = 2). As the majority of subjects correlated strongly or moderately, the participants' GPA was calculated and used as the outcome measure in the present study. Further, by using a GPA, the influence of the parents' possible uncertainties of the grades were minimized. The GPA is a mean score of the participants' gradings in the different school subjects. In an online questionnaire, the parents of the participating children were asked to report the school grades their child received in the spring of 2020. The questionnaire was created in three slightly different versions to fit children of different age groups regarding school subjects and type of grading. Parents of children at school grades 1–3 were asked about the child's grades in Swedish, Finnish, English, mathematics, and environmental science/biology. In addition to these, parents of children at grades 4–7 and 9 were also asked about the child's grade in history. For the youngest group, children in grades 1–3, verbal grading was reported by parents through written text. For children in grades 4–7, the reporting could be either in numbers or in text, and for children at grade 9 solely in numbers. Furthermore, information regarding how the

COVID-19 pandemic affected the children's schooling and the parents' working life were collected in the questionnaire, but this information is not described and analysed in the present study.

The majority of children in the present study had received numeric grades (see Table 3). Regarding mathematics, Swedish, Finnish, and biology no grade was reported for 1–8 children. Regarding English no grade was given for 26 children and regarding history no grade was given for 47 children. This might be due to the parents not remembering the grade or that the child was not taught in the subject at hand.

Table 3

Proportion of Verbal and Numeric Gradings for Each School Subject

	Verbal grading		Numeric grading	
School Subject	*N*	%	*n*	%
Mathematics	39	36.4	68	63.6
Swedish	38	35.2	70	64.8
Finnish	33	32.4	69	67.6
English	18	21.7	65	78.3
Biology	34	33.7	67	66.3
History	7	11.3	55	88.7

Note. The percentage for each subject and type of grading (verbal/numeric) is calculated based on the number of children for whom a grade in the subject was reported.

Assessment of Intelligence and Working Memory

The WISC-V is a psychological test used to measure cognitive ability in children aged 6:0–16:11 years (Wechsler, 2014a). The WISC-V consists of a Full Scale IQ (FSIQ) and five primary indexes. In addition, five Ancillary Indexes can also be calculated. All of these have a mean score of 100 and a standard deviation (SD) of 15. In the present study, the Working Memory Index (WMI) which is a primary index, and the General Ability Index (GAI) which is an ancillary index were used. The Wechsler scales have been translated and adapted to several languages and separate norms for these have been established. A Scandinavian normative sample for the Swedish version of the test has been gathered in Sweden, Norway, and Denmark. The FinSwed Study used the Swedish version of WISC-V together with the Scandinavian norms. WISC-V has good reliability and validity, which has been shown in the

Scandinavian normative sample (Wechsler, 2014a) and in the American normative sample (Wechsler, 2014b).

In the present study, IQ was measured with the GAI and WM with the WMI. The GAI consists of the five subtests Block Design, Figure Weights, Matrix Reasoning, Vocabulary, and Similarities. Since the GAI provides an estimate of general intelligence that is less impacted by WM and processing speed, relative to the FSIQ, it was used as the measure of IQ in the present study (Wechsler, 2014a). The other index used in the present study, namely the WMI, is calculated on the basis of two subtests, Digit Span and Picture Span. The subtest Digit Span represents a measure of verbal STM and WM, and Picture Span is a measure of visual STM and WM (Wechsler, 2014a). The WMI measures a child's ability to register, maintain and manipulate visual and auditory information. Besides memory skills, these tasks require skills in attention, concentration, and mental reasoning as well as visual and auditory discrimination (Wechsler, 2014a).

Modifications of WISC-V

The measures used in the present study were subtests from the Swedish version of WISC-V. No test versions have been created specifically for the Swedish-speaking population in Finland. Since some of the tasks included cultural information and words that are unusual in Finland-Swedish, minor changes in WISC-V were made to fit the Finland-Swedish children better. In the Information subtest, the two country-specific questions about Sweden were changed to country-specific questions about Finland. Additionally, adaptations in the phrasing of a few questions were made.[1]

Background Variables

In conjunction with the cognitive assessment, the parents of the participating children filled out a background questionnaire regarding the child's language and day care background as well as possible disorders and medications. Additionally, questions regarding the parents' first language and level of education were included.

Data Preparation and Statistical Analyses

Statistical analyses were conducted using IBM SPSS Statistics version 27.0. For five of the subtests in WISC-V, data was imputed on item level. This was done for six children due to missing data for specific items (1 subtest/child). Reasons behind the missing data were

[1] All changes were made according to the Statement of Work No. 296412 to Master License Agreement No. LSR–111089 with NCS Pearson.

for example errors in the administration of a subtest. Additionally, data for three subtests were imputed on subtest level. This was done for two children, who had not participated in these subtests (1 respectively 2 subtests per child).

Verbal and Numeric Grading Scales

The parents of the participating children were asked to describe the verbal grading scale that was used in the school of their participating child. Several different verbal grading scales are in use in Finland, both considering the number of levels and the labels used. Not all parents reported the verbal grading scale. In order to clarify these uncertainties, the headmasters of the involved schools were contacted. They were asked to describe the number of levels on the verbal grading scale used at their school, and what the different levels were called. In total, eight headmasters were contacted and six of them replied. Additionally, the Finnish National Agency for Education was contacted regarding the same matter. A coherent verbal grading scale with five levels was created based on information from all of the sources mentioned above.

The numeric grading scale used in Finland consists of seven levels (4–10, where 4 is considered fail), and therefore the verbal grading scale consisting of five levels had to be restructured to match it, in order to enable all participants to be included in the same statistical analyses. The verbal grading scale was transformed to a corresponding numeric grading scale, shown in Table 4. We chose to match the highest level of the verbal grading scale, which was “excellent”, with a calculated mean of grade 9 and 10, and the middle level on the verbal grading scale, which was “satisfactory”, with the mean of 6 and 7. Two parents had reported that the verbal grading scale for Finnish was “pass or fail” only. For these two cases, the grades in Finnish were not taken into account in the analyses due to the difficulty in transforming them into a corresponding numeric grading.

Table 4

Verbal and the Constructed Numeric Grading Scales

Verbal grading scale	Numeric grading scale
Excellent	9.5
Good	8
Satisfactory	6.5
Sufficient	5
Fail	4

Note. The numeric grading scale includes 6.5 and 9.5 as a result of the transformation of verbal gradings into numeric gradings.

In two cases, both the child's mother and father had filled out the questionnaire regarding grading of school performance. In these cases, the mother and father had reported different grades for some subjects. A mean of the reported grades was then calculated and used in the statistical analyses. Regarding verbal grading for Swedish and mathematics among children in grades 1–3, it was possible for the parents to report grades for different subareas within the subject, if such existed. Common subareas reported for Swedish were reading, writing, communication, and reading comprehension. Common subareas reported for mathematics were problem solving, mechanical counting, mathematical thinking, and the basics of geometry. A mean of the grades in the subareas was calculated and used as the grade for the whole subject.

After the modification of verbal gradings into the numeric grading scale, the GPA for each participant was calculated. In Table 5, the GPA's together with the mean score of the different subjects are presented.

Table 5

GPA and Subject Means of the Participating Children

	n	*M*	Range
GPA [1]	109	8.55	6.5–10
GPA, verbal gradings	40	8.41	6.5–9.5
GPA, numeric gradings	69	8.63	6.8–10
Mathematics	107	8.72	6–10
Swedish	108	8.43	6.5–10
Finnish	102	8.41	6–10
English	83	8.75	6.5–10
Biology	101	8.58	6.5–10
History	62	8.66	7–10

Note. GPA = Grade point average. Grades in history were only given at grade levels 4–9. Additionally, the majority of children did not have grades in English at grade levels 1–3.

[1] Verbal and numeric gradings combined

Statistical Analyses

An independent samples t-test and contingency table analyses (Chi-Square tests) were conducted to investigate if there were significant differences between the participants and non-participants regarding gender and language (mono-/bilingual).

One-way independent ANOVAs were conducted to investigate if there were main effects of either maternal or paternal education on the child's GPA, GAI, or WMI.

Bivariate correlations were conducted to investigate the relationship between school grades (GPA and grades for the different school subjects separately) and the GAI or WMI. Since the grades in the different subjects were not normally distributed, Spearman's correlation was administered.

To investigate the predictive power of IQ and WM on learning outcomes, hierarchical regression analyses were conducted. Initially, the assumptions of linear regression were analysed. The dependent variable (GPA) followed a normal distribution, both according to normality tests and P-P plots. Both Kolmogorov-Smirnov (p = .154) and Shapiro-Wilk were non-significant (p = .113) for GPA, indicating that the sample distribution was normal. The assumption regarding homogeneity of residuals were also met. Another assumption for linear regression with multiple predictors is that they should not correlate too highly (r > .80–.90). In this study, there was a positive correlation between the two predictor variables (r_s =.52; p

<.001). This correlation is moderate and, therefore, it does not violate the assumption. Lastly, to check for possible multicollinearity, the VIF and tolerance statistics were analysed, and no concerns unfolded (Field, 2013).

In the hierarchical regression analyses, GPA was used as a measure of learning outcomes, the GAI as a measure of IQ and the WMI as a measure of WM. The predictor variables were first entered in one order (the GAI followed by the WMI) and then in the reverse order (the WMI followed by the GAI) to examine the variance accounted for by each variable in addition to the other. Apart from the main regression analyses, two other regression analyses were conducted: One with children in grade 2–5 (n = 48), and one with children in grade 6–9 (n = 61). These analyses were conducted to investigate if there were differences in the predictive power of WM and IQ in younger versus older children. In the group with younger participants, in total 70.8% had received verbal grading in at least one subject. In the group with older participants, in total 9.8% had received verbal grading in at least one subject.

Results

Background Analyses

In the one-way independent ANOVAs, there were no significant main effect of maternal education on the child's GPA ($F(2,104) = 1.22$, $p = .299$), GAI ($F(2,104) = .46$, $p = .633$), or WMI ($F(2,104) = .07$, $p = .929$). Furthermore, there were no significant main effect of paternal education on the child's GPA ($F(2,106) = .57$, $p = .57$), GAI ($F(2,106) = .47$, $p = .626$), or WMI ($F(2,106) = .44$, $p = .644$).

The GAI showed significant positive correlations with all school grades separately, as well as with the GPA. The WMI showed significant positive correlations with mathematics, Swedish, biology, and history, as well as with the GPA (see Table 6).

Table 6

Spearman's Correlation Coefficients Between the Subject Grades, the GAI, and the WMI GAI, the WMI, GPA, and Subject Grades

Variable	GPA *N* = 109	Mathematics *n* = 107	Swedish *n* = 108	Finnish *n* = 102	English *n* = 83	Biology *n* = 101	History *n* = 62
GAI	.49**	.47**	.42**	.24*	.29*	.24*	.41*
WMI	.34**	.34**	.28*	.10	.17	.29*	.34*

Note. GPA = Grade point average; GAI = General Ability Index; WMI = Working Memory Index. *p = <.05. **p = <.001.

Main Results

In the first model in the regression analyses, the GAI was entered in the first step, followed by the WMI. The GAI accounted for a significant proportion of variance (24.8%) in GPA, whereas the additional variance accounted for by the WMI at the next step (0.8%) was not statistically significant. In the second model, the WMI was entered at the first step and accounted for 11.3% of the variance. The GAI accounted for an additional significant variance of 14.3%. In this second model, the variance accounted for by both the WMI and the GAI was significant. In summary, the results showed that the variance accounted for by the WMI was only significant when the variable was entered first into the model, whereas the variance accounted for by the GAI was significant independently of whether it was entered in the first or second step (see Table 7).

Table 7

Hierarchical Regression Analyses Predicting Learning Outcomes Measured by GPA (N=109)

	B	95% CI		*SE B*	*β*	*t*	*p*	R^2	Adj. R^2	*F*
		LL	*UL*							
Model 1										
Step 1: GAI	.027	.018	.035	.004	.498	5.94	**.000**	.248	.241	35.24
Step 2: WMI	.005	-.004	.015	.005	.105	1.07	.288	.256	.242	18.31
Model 2										
Step 1: WMI	.016	.008	.025	.004	.336	3.69	**.000**	.113	.105	13.64
Step 2: GAI	.024	.013	.034	.005	.443	4.51	**.000**	.256	.242	18.21

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit; GAI = General Ability Index; WMI = Working Memory Index; Adj. R^2 = Adjusted R^2. Significant *p*-values are bolded.

Subanalyses

Two subanalyses were also conducted. One with children in grades 2–5 and one with children in grades 6–9.

Children in Grade 2–5

When the GAI was entered at the first step, followed by the WMI at the second step, the GAI accounted for 24.8% and the WMI for an additional 0.2% of the variance of GPA. The variance accounted for by the GAI was significant, whereas the variance accounted for by the WMI was not. When the factors were entered in the opposite order, the WMI accounted for 6.2% of the variance and the GAI for additional 18.8%. Only the variance accounted for by the GAI was significant (see Table 8).

Table 8

Hierarchical Regression Analyses Predicting Learning Outcomes Measured by GPA Among Children in Grades 2–5 (n = 48)

	B	95% CI		*SE*	*β*	*t*	*p*	R^2	Adj. R^2	*F*
		LL	*UL*							
Model 1										
Step 1: GAI	.024	.011	.036	.006	.498	3.90	**.000**	.248	.232	15.19
Step 2: WMI	-.002	-.018	.013	.008	-.047	-.30	.766	.250	.216	7.49
Model 2										
Step 1: WMI	.012	-.002	.026	.007	.250	1.75	.087	.062	.042	3.06
Step 2: GAI	.025	.010	.040	.007	.525	3.35	**.002**	.250	.216	7.49

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit; GAI = General Ability Index; WMI = Working Memory Index; Adj. R^2 = Adjusted R^2. Significant *p*-values are bolded.

Children in Grade 6–9

When the GAI was entered at the first step, followed by the WMI at the second step, the GAI accounted for 19.6% and the WMI for additional 3.0% of the variance in GPA. The variance accounted for by the GAI was significant, whereas the variance accounted for by the WMI was not. When the factors were entered in the opposite order, the WMI significantly accounted for 13.9% of the variance and the GAI significantly for an additional 8.7% (see Table 9).

Table 9

Hierarchical Regression Analyses Predicting Learning Outcomes Measured by GPA Among Children in Grade 6–9 (n = 61)

	B	95% CI		*SE B*	*β*	*t*	*p*	R^2	Adj. R^2	*F*
		LL	*UL*							
Model 1										
Step 1: GAI	.025	.012	.038	.006	.443	3.79	**.000**	.196	.182	14.38
Step 2: WMI	.010	-.003	.022	.006	.200	1.50	.140	.226	.199	8.46
Model 2										
Step 1: WMI	.018	.006	.029	.006	.372	3.08	**.003**	.139	.124	9.49
Step 2: GAI	.019	.004	.034	.007	.342	2.56	**.013**	.226	.199	8.46

Note. CI = confidence interval; *LL* = lower limit; *UL* = upper limit; GAI = General Ability Index; WMI = Working Memory Index; Adj. R^2 = Adjusted R^2. Significant *p*-values are bolded.

Discussion

The aim of this study was to investigate the degree to which IQ and WM predict learning outcomes in a population of Swedish-speaking Finnish school-aged children. The previous research findings on this matter are mixed. Some studies indicate that IQ, compared to WM, has greater predictive power on learning outcomes (Giofrè et al., 2017), and other suggest the opposite (Alloway & Alloway, 2010; Siquara et al., 2018). All in all, though, most studies indicate that WM skills are a stronger predictor for learning outcomes compared to IQ, and therefore it was hypothesized that WM would have greater predictive value also in the present study. The main findings in this study point toward the opposite, namely that IQ has stronger predictive power on school grades than WM. Moreover, this was the case both for younger and older children (children in grades 2–5 and 6–9), suggesting that the direction of the effect is similar independent of age and developmental stage.

The Predictive Value of IQ and WM in Learning Outcomes

In the present study, learning outcomes were measured with teacher-assigned school grades, as opposed to achievement tests used in many previous studies. IQ was measured with the GAI and WM with the WMI from WISC-V. The results in the main analyses suggest that the predictive power of IQ on teacher-assigned school grades is stronger compared to the predictive power of WM. The variance accounted for by IQ was statistically significant irrespective of if it was entered into the hierarchical regression model before or after WM.

The variance accounted for by WM was significant only when it was entered first. If it was added to the regression model after IQ, the effect of WM was practically nonexistent. The regression analyses with children in grade 2–5 and 6–9 separately, pointed to the same direction as the main analyses. In both age groups, IQ accounted for the largest amount of variance, and this contribution was significant in all models. WM, however, was not a statistically significant predictor for learning outcomes among the younger children. Among the older children, WM was only significant when it was entered into the model before IQ. Hence, the results indicate that the predictive power of IQ on teacher-assigned school grades is stronger than that of WM, and that the effect of WM is stronger among children in grade 6–9 compared to children in grade 2–5.

In the main regression analysis, with all participants included, the variance accounted for by the GAI and the WMI differed depending on which predictor was entered first in the model. When the GAI was entered at the first step it significantly accounted for 24.8% of the variance in GPA. When WMI on the other hand was entered at the first step it significantly accounted for 11.3% of the variance in GPA. This is a notable difference, but the difference is even greater when comparing the variance that the two predictors accounted for when entered in the second step. When the GAI was entered after the WMI it still significantly accounted for an additional variance of 14.3%. When the WMI was entered after the GAI it only accounted for an additional variance of 0.8%, which is remarkably little.

The subanalyses with younger participants (children in grade 2–5) followed the same pattern as the main analysis. The variance accounted for by the GAI was always greater than the variance accounted for by the WMI, irrespective of whether the variable was entered in the first or second step. The subanalyses with older participants (children in grade 6–9) on the other hand, did not follow the same pattern. When the WMI was entered at the first step it accounted for a larger proportion of variance compared to the GAI, which was not seen in the other models. Just as in the main analysis, the variance accounted for by the WMI was remarkably small among children in grade 2–5. This suggests that WM skills have a greater influence on school grades among older students.

These results contradict the findings by Caemmerer et al. (2018) who reported that WM was particularly important for achievement skills in younger children. Contradictory to our findings, Roth et al. (2015) found slightly higher correlations between IQ and school grades among children in middle and high school, compared to children in elementary school. They suggested that it might be easier to compensate for deficits in IQ in lower grades than in higher grades, since the learning material often is more limited. Based on our results, we suggest that since older children must learn and remember great quantities of information during the school year, WM may be associated to grades more among older than younger children. However, these differences may also be explained by how learning outcomes were measured. Caemmerer et al. (2018) used the achievement test WIAT to measure learning outcomes, whereas Roth et al. (2015) and the present study used GPA. The effect of IQ and WM might be reflected more clearly in school grades as compared to in achievement tests, which often assess specific abilities of for example reading or mathematics at a specific time point.

All in all, the variance accounted for by the GAI was significant independently of whether it was entered in the first or second step. This was the case in both the main analysis and in the subanalyses. The variance accounted for by the WMI was only significant in the main analysis and in the analysis with older children when it was entered in the first step. The variance accounted for by the WMI was in other words always nonsignificant in the analysis with younger children.

Differences Between this Study and Previous Studies

Differences Regarding Measures of Learning Outcomes, IQ, and WM

Previous findings on the predictive power of IQ and WM on learning outcomes are mixed. The previous studies have used different measures of both learning outcomes, IQ, and WM, which might be a factor contributing to the dissensus. The outcome variable, learning outcomes, have been measured in different ways in previous studies. In the present study, teacher-assigned school grades in six major subjects were used (mathematics, Swedish, Finnish, English, biology, and history). Previous studies have focused mainly on achievement tests in mathematics and reading (Alloway & Alloway, 2010; Caemmerer et al., 2018; Giofrè et al., 2017; Siquara et al., 2018). However, school grades were also used in the meta-analysis conducted by Roth et al. (2015). On one hand, school grades give a broader picture of the child's knowledge since they measure more than mathematics and reading skills. On the other hand, school grades, which are set over a longer time, are more influenced by motivation compared to achievement tests conducted at a specific time point (Sternberg et al., 2001), which may explain some of the differences in the results between this study and previous studies (Alloway & Alloway, 2010; Caemmerer et al., 2018; Giofrè et al., 2017; Siquara et al., 2018).

In the present study a GPA of the school subject grades was calculated and used in the statistical analyses. Roth et al. (2015) chose to group the separate subjects into domains when investigating IQ as a predictor for school grades (e.g., the domain Mathematics and Science including subjects such as mathematics, biology, and physics). The use of solely a GPA gives a quite straight forward overview of the influence of IQ and WM on learning outcomes, but this overview might be a bit simplified. Using domains as the outcome variable instead could give more detailed information of which types of subjects that are influenced more versus less by IQ and WM. However, since the different subjects were strongly correlated, an average of the subject grades (GPA) was used. Using the child's overall school achievement as the outcome measure also has clinical implications, as it provides an overview of the relationship between IQ, WM, and learning and easily can be taken into account in clinical assessments.

In the present study, the participants were gathered from several different municipalities and schools. There has been shown to be variation in how teachers from different municipalities grade their students (The Finnish National Agency for Education, 2020b), and variation is, to some extent, also likely to occur among teachers within the same school. Similarly, there may be variation in gradings between different countries. This is of relevance here, since the previous studies have gathered their samples in different countries. However, we lack information about the magnitude or direction of these possible grading differences.

In this study, the first predictor variable, IQ, was measured with the GAI. This might be seen as a strength, since it is a rather comprehensive measure of general intelligence, consisting of five WISC-V subtests, at the same time as it is less impacted by WM compared to the FSIQ (Wechsler, 2014a). The use of the FSIQ would have been possible, but that would have affected the statistical analyses in an undesirable way. The variance accounted for by the FSIQ would have been disproportionately large compared to the WMI, since it also includes a subtest from the WMI. Thereby, the results would not have been as reliable.

Instead of using an already existing measure of IQ, Alloway and Alloway (2010) and Siquara et al. (2018) used solely a few subtests (1–3) from WPPSI-R and WISC-III. The subtests Block Design and Vocabulary, which they both used, are a part of the GAI but can be considered to be a weaker measure of IQ, since the GAI is more comprehensive. In the study by Giofrè et al. (2017), IQ was measured with the Cattell Culture Fair Intelligence Test and Primary Mental Abilities. In summary, the results by Giofrè et al. (2017) and the present study, in which both an existing measure of IQ was used, IQ was shown to be a stronger predictor of learning outcomes compared to WM. The studies that did not use an existing measure of IQ (Alloway & Alloway, 2010; Siquara et al., 2018), and instead solely used a few subtests from WISC-III and WPPSI-R, showed opposite results, namely that WM was the stronger predictor. This leads to the question of how reliable it is to base a measure of IQ on only two or three subtests.

In the meta-analysis by Roth et al. (2015) it was found that mixed IQ tests showed a higher population correlation with school grades compared to solely verbal or nonverbal IQ tests. Even though several of the studies mentioned above have used quite narrow measures of IQ, they have included both verbal and nonverbal tasks, which is preferable according to the findings by Roth et al. (2015). Furthermore, they have tried to avoid including tests of memory in their measures of IQ, which is to prefer in order to achieve a stable statistical model.

The second predictor variable, namely WM, has also been measured in different ways in previous studies. In the present study, WM was measured with the WMI from WISC-V, comprising of Digit Span (forward, backward, and sequencing versions) and Picture Span. Picture Span and the forward version of Digit Span could be considered more as measures of STM than WM, whereas Digit Span backwards and sequencing are more clearly measures of WM. However, in the WISC-V manual these subtests are presented as verbal and visual measures of both STM and WM, simultaneously (Wechsler, 2014a). Alloway and Alloway (2010) chose to solely use verbal tasks to measure STM and WM, whereas Siquara et al. (2018), and Giofrè et al. (2017) used both verbal and visual tasks. In the statistical analyses, Alloway and Alloway (2010) looked at the effect of STM and WM on learning outcomes separately, whereas a distinction between these measures were not made by Siquara et al. (2018).

Even though STM and WM are different theoretical concepts, the distinction between them is not always clear (Aben et al., 2012), which is reflected in the several different ways that the previous studies have chosen to measure WM. Even though there are differences in how the previous studies have measured WM, there are also similarities. All the presented studies except for one (Alloway & Alloway, 2010) used tests of both verbal and visual memory. Furthermore, all presented studies used versions of either Digit Span and/or word recall as part of the measure of WM.

Differences Regarding Participants

The participants in the present study were typically developing children without learning difficulties. Similarly, Alloway and Alloway (2010) only included typically developing children in their study. Siquara et al. (2018), Giofrè et al. (2017), and Caemmerer et al. (2018) did not specify whether their samples included children with learning difficulties or not. However, Siquara et al. (2018) reported that only children without any health problems were included in their study and Giofrè et al. (2017) reported that only children without clinical diagnoses were included in their study. In other words, both the present study and the previous studies described above seem to have had quite similar samples with relatively typically developing children. Even though this contributes to the comparability of the results between the studies, the fact that the present study consisted of typically developing children without learning difficulties and formal support in school is important to take into consideration when interpreting the present results. Because of this we can assume that the children in the present study performed better both in school and in the cognitive assessments compared to Finland-Swedish pupils overall. Additionally, the educational level of the participants' parents was higher than the average among Finland-Swedes (Saarela, 2021). One could speculate whether the influence of IQ and WM would have been different if the sample was more heterogenous by also including children with learning difficulties or formal support in school. future studies are needed to confirm the findings.

The age of the participants in the present study were comparable to the ages of the participants in the previous studies described. The participants in this study were 7:11–16:4 years. The participants in the previous studies were in the age range 6–16 years (Giofrè et al. 2017, Siquara et al. 2018, Caemmerer et al. 2018). However, the participants in the longitudinal study by Alloway and Alloway (2010) were somewhat younger (4.3–5.7 years of age at Time 1 and 10.0–11.3 at Time 2).

Differences Regarding Statistical Methods and Results

Similar results of correlations between IQ and learning outcomes as in the present study have been reported in previous studies (e.g., Roth et al. 2015 and Siquara et al., 2018). Roth et al. (2015) found a correlation of $r = .44$ between IQ and a mean of school grades (Mathematics and Science, Languages, and Social Sciences) compared to the correlation of $r = .49$ between IQ and GPA in the present study. In the meta-analysis by Roth et al. (2015) the school subjects were clustered into domains. A correlation of $r = .42$ was found between IQ and the domain Mathematics and Science (including e.g., mathematics, biology and physics). In the present study such domains were not created, but a correlation between IQ and mathematics of $r = .47$ and a correlation of IQ and biology of $r = .24$ were found. Since the majority of the participants in the present study did not yet study physics, grades in that subject were not collected. Furthermore, Roth et al. (2015) found a correlation between IQ and the domain Languages (e.g., English, reading, and literature) of $r = .36$. The correlation found between IQ and Swedish in the present study, namely $r = .42$, is quite similar. Additionally, Siquara et al. (2018) found a correlation of $r = .42$ between IQ and reading.

Looking into correlations between WM and school subjects, larger correlations were found by Siquara et al. (2018) compared to the ones found in the present study. Siquara et al. (2018) found WM to correlate with arithmetic at $r = .61$ and with reading at a level of $r = .38$. Furthermore, they reported a correlation of $r = .45$ between IQ and a mean of results in tests of arithmetic, reading and spelling. In the present study WM was found to correlate with GPA at a level of $r = .34$, with mathematics at $r = .34$ and with Swedish at a level of $r = .28$. The outcome variables in these two studies do not exactly correspond to each other due to differences in ways of measuring them, which might explain the differences in the sizes of the correlations. Siquara et al. (2018) measured arithmetic and reading at one single point with achievement tests, whereas mathematics and Swedish were measured with grades set over a longer time in the present study.

Siquara et al. (2018) did not only find larger correlations compared to the present study, the variance accounted for by STM and WM was also larger than the variance in the present study. According to their results, STM and WM together accounted for 37% of the variance, and IQ for 19% of the variance in learning outcomes. In the present study, the variance in learning outcomes accounted for by both IQ and WM was 25.6%, which is lower than the variance accounted for by solely the memory tests in the study by Siquara et al. (2018).

When Alloway and Alloway (2010) analysed their data, they entered the two predictors (IQ and WM) into a regression model in the same way as in the present study. That is, first in one order and then in the reverse order. However, they conducted separate regression analyses with numeracy respectively literacy as outcome variables. Their results showed that the variance accounted for by WM was greater than the variance accounted for by IQ, independently of it was entered at the first or second step. In the present study, opposite results were found. The difference in these results might be due to several reasons, ranging from type of measure of learning outcomes, IQ, and WM to the fact that Alloway and Alloway (2010) conducted a longitudinal study.

In sum, results are bound to vary depending on how learning outcomes were defined, how the predictor variables were measured, and how the data was statistically analysed. Further, the inclusion and exclusion criteria for the sample affects its heterogeneity and, hence, the generalizability of the results. Additionally, results may vary between younger and older children.

Clinical Implications

The results in the present study indicate that IQ has greater predictive power over learning outcomes than WM. Hence, the relationship between IQ and learning outcomes has been corroborated in Swedish-speaking Finnish school-aged children. Knowledge about this relationship is of clinical importance when combining assessment results with information from the classroom in order to plan for proper support in school. Furthermore, these results confirm that cognitive assessments can be used as a basis for planning educational support. In this study it was also found that WM is associated with learning outcomes, but to a smaller extent than IQ. Since poor WM skills early on might lead to problems with the learning process (Gathercole et al., 2006a) and to difficulties in the classroom (Gathercole et al., 2006b) early recognition and intervention is important.

However, it is important to acknowledge that IQ and WM together only accounted for approximately one fourth of the variance in learning outcomes. There are, in other words, still several factors besides these that the clinician needs to consider when interpreting possible reasons behind clinical test results. For instance, it has previously been suggested that academic self-esteem is one of these (Giofrè et al., 2017).

Limitations

In the present study, there are some limitations that need to be acknowledged. First, parents did not always had access to the children's grades and therefore some of the parents did not report any/all grades. Some of the parents that did report grades wrote in a comments section that they were a bit unsure about their answers, but that they answered as correctly as they remembered. As a result of this, the reported grades might be slightly unreliable. However, in order to minimize the effect of this uncertainty, a GPA was calculated and used in the statistical analysis.

Second, different systems for verbal grading were used in different schools. Therefore, some adjustments had to be made in the present study in order to create a coherent verbal grading scale. This scale, consisting of five levels, was then restructured to match the numeric grading scale with seven levels used in Finland. This was done to enable all participants to be included in the same statistical analyses. Further, the GPA of the children who had received verbal gradings and the children who had received numeric gradings were almost the same. Since the performance in these two groups were so similar, the transformation of verbal grades to numbers seemed to be reliable. Another way to include all children in the same analysis could not be found.

Thirdly, due to the COVID-19 pandemic and its societal restrictions, some WISC-V assessments (n = 8) were held with a longer interval between the sessions. Since a new test age was counted for the latter sessions and the relevant subtests were scored according to the new test age in these cases, this should not have impacted the results markedly.

Fourth, the assessments were conducted by several different persons, both by clinical psychologists and psychology students and therefore differences in administration and scoring might have occurred. However, an arranged schooling for the psychologists and research assistants were held before the assessments took place. Furthermore, the assessment protocols were reviewed at random and corrected, if necessary. Administration errors and missing data were imputed on item and subtest levels, which might have had an impact on the results. However, data was imputed for only 7% of the participants.

Lastly, since the sample in the present study consisted of typically developing children without learning difficulties, the results may not be directly attributable to a clinical sample.

Conclusions

The present study investigated the predictive power of IQ and WM on learning outcomes in typically developing school-aged children in Finland. IQ and WM together explained a fourth of the variance in school grades. IQ had greater predictive power than WM. As test results from IQ tests are commonly used to make decisions about school placements and educational support, it is important for clinicians that the association between IQ and school achievement has been demonstrated. Based on the present study, using IQ tests when clinically planning educational support seems to be relevant. However, there are still several other factors that could influence learning outcomes to a high degree and that must be considered in a clinical assessment. Socioeconomic status (Sirin, 2005), motivational factors (Weber et al., 2013), and the school climate (Kutsyuruba et al., 2015) are some examples of these.

Swedish Summary – Svensk sammanfattning

Intelligens och arbetsminne som prediktorer för skolresultat hos barn i skolåldern

Det finns stor variation i elevers skolresultat, och flera faktorer, både kognitiva och icke-kognitiva, är förknippade med denna variation (Chiesi & Primi, 2010). När det gäller kognitiva faktorer spelar intelligens och arbetsminne viktiga roller för skolprestationen, men frågan är vilken av dem som är viktigast. Forskningsresultaten i anslutning till detta pekar i olika riktningar. Vissa studier tyder på att arbetsminne, i motsats till intelligens, är en starkare prediktor för skolresultat (Alloway & Alloway, 2010; Siquara et al., 2018), medan andra studier tyder på det motsatta (Giofrè et al., 2017).

Skolresultat, intelligens och arbetsminne

Syftet med att bedöma elevers skolprestationer är att definiera i vilken utsträckning eleven har uppnått de uppsatta målen för ämnet i fråga och att uppmuntra eleven i studierna. Utbildningsstyrelsen ger riktlinjer för betygsättning av skolprestationer i Finland. Elever i årskurs 1–3 betygsätts antingen muntligt eller numeriskt i enlighet med utbildningsanordnarens direktiv. Elever i årskurs 4–9 ges i allmänhet numeriska vitsord. Verbal betygsättning kan dock ges som ett komplement till de numeriska vitsorden för dessa elever. Den numeriska betygsskalan sträcker sig från 4 till 10, där 5 är det första vitsordet som anses vara godkänt. Den verbala betygsskalan å andra sidan kan bestå av olika antal nivåer beroende på utbildningsanordnaren. Skalan kan till exempel bestå av fem nivåer (underkänd, osäker, nöjaktig, god, berömlig).

Amerikanska psykologförbundet (eng. American Psychological Association; u.å.) definierar intelligens som förmågan att härleda information, lära sig av erfarenheter, anpassa sig till omgivningen och korrekt använda tanke och förnuft. Intelligenskvoten (IK, vanligen förkortat IQ) är ett standardmått på en individs intelligensnivå baserat på individuellt administrerade psykologiska test. Testerna består av uppgifter som avser att mäta inlärning, abstraktionsförmåga och problemlösningsförmåga. Forskning pekar på ett starkt samband mellan IQ och skolresultat (Sternberg et al., 2001; Deary et al., 2007). Vidare har det hävdats att IQ är en nyckelfaktor som ligger till grund för kopplingen mellan arbetsminne och inlärning (Nation et al., 1999; Stothard & Hulme, 1992), men å andra sidan finns det även studier som tyder på att arbetsminnet har unika kopplingar till inlärning (Gathercole et al., 2006a; Cain et al., 2004).

Arbetsminnet är ett system som gör att vi kan bearbeta information och lagra den tillfälligt (Baddeley, 2000). Vidare är arbetsminnet involverat i många komplexa uppgifter, såsom problemlösning, läsförmåga och matematiskt resonerande (Baddeley & Hitch, 1974). I ett klassrum kan problem med arbetsminnet leda till olika svårigheter, exempelvis svårigheter med att komma ihåg instruktioner läraren ger muntligt (Gathercole et al., 2006b). I vissa fall feldiagnosticeras problem med arbetsminnet som uppmärksamhetsproblematik och i vissa fall upptäcks inte problemen alls (Gathercole et al., 2006a). Rätt diagnos och tidiga insatser är viktiga för att stödja barnet och för att minska risken för efterföljande inlärningsproblem. I klassrummet kan arbetsminnesbelastningen minskas på flera sätt, till exempel genom att läraren upprepar instruktioner, förenklar komplicerade uppgifter och hjälper barnet med mentala strategier (Gathercole et al., 2006b). Ett barns arbetsminneskapacitet kan tillförlitligt mätas från fyra års ålder (Alloway et al., 2004) och måttet ger information om barnets inlärningsförmåga (Alloway et al., 2005; Engel et al., 2008). Arbetsminneskapaciteten kan mätas med uppgifter som exempelvis går ut på att återkalla en rad upplästa siffror i omvänd ordningsföljd (Alloway & Alloway, 2010).

Skolresultat i relation till intelligens och arbetsminne

Flera studier har påvisat att IQ har en betydelse för inlärning (Sternberg et al., 2001; Deary et al., 2007). Därtill har andra studier påvisat att även arbetsminnet har en betydelse för inlärning (Gathercole et al., 2006a; Engel et al., 2008). Flera studier har undersökt IQ och arbetsminne som prediktorer för skolresultat.

Resultaten i en studie av Alloway och Alloway (2010) indikerade att barns arbetsminne är en starkare prediktor än IQ för skolresultat. Även Siquara et al. (2018) kom till samma resultat i sin studie då den prediktiva styrkan hos IQ och arbetsminne för skolresultat undersöktes. Giofrè et al. (2017) valde att undersöka sambandet mellan IQ, arbetsminne, akademisk självkänsla och skolresultat. Resultaten indikerade att skolresultat påverkas av både kognitiva och icke-kognitiva faktorer. Inom de kognitiva faktorerna var IQ en starkare prediktor än arbetsminne för skolresultat. Utöver detta pekade resultaten på att akademisk självkänsla (medierat av IQ) har en indirekt inverkan på skolresultat. Vidare har Caemmerer et al. (2018) studerat effekterna av kognitiva förmågor för barns och ungdomars skolresultat. Resultaten indikerade att arbetsminne var särskilt viktigt för yngre barn. Dessutom indikerade resultaten att IQ hade en stark inverkan på skolresultaten.

Studiens syfte

Syftet med denna studie var att undersöka den prediktiva styrkan hos IQ och arbetsminne för skolresultat i en population av finlandssvenska barn i skolåldern. Trots att det inte råder entydig konsensus om huruvida IQ eller arbetsminne har starkast prediktiv inverkan på skolresultat, indikerar de flesta studier att arbetsminnets roll är viktigare (Alloway & Alloway, 2010; Siquara et al., 2018; Caemmerer et al., 2018). Därmed fastslogs hypotesen att arbetsminnets prediktiva roll skulle komma att vara starkare även i denna studie. Kunskap om dessa samband är av betydelse i kliniska sammanhang, exempelvis då resultat från en psykologisk testning jämförs med skolvitsord och hur barnet klarar sig i skolan.

Metod

Denna studie är en understudie till FEST-projektet (*Finlandssvenska elevers prestationer i svenska test*) som undersökt hur finlandssvenska barn i åldern 5–16 år presterar i de svenska versionerna av WPPSI-IV, WISC-V och delar av NEPSY-II. Etiskt lov för FEST-projektet gavs i juni 2019 av Etikprövningsnämnden för humaniora och samhälls- och beteendevetenskaper vid Helsingfors universitet. I augusti 2020 gavs ett ytterligare tillstånd till att samla in ytterligare data för denna delstudie.

I denna studie deltog barn i åldern 7:11–16:4 (M = 12,31, SD = 2,48) år. Åldrarna rapporteras i enlighet med åldern vid det första utredningstillfället. Samplet samlades in i fyra tvåspråkiga regioner (Österbotten, Åboland, huvudstadsregionen och övriga Nyland) genom ett stratifierat urval. Det slutliga samplet i denna studie bestod av 109 barn, varav 61 (56,0 %) var enspråkigt svenskspråkiga och 48 (44,0 %) var tvåspråkiga (svenska och finska). Barnen som inkluderades i studien var typiskt utvecklade. Till uteslutningskriterierna i FEST-projektet hörde att barnet hade genomgått en kognitiv utredning under de senaste 6 månaderna, blev utrett eller deltog i (re)habilitering för tillfället eller var i kö för utredning. Ytterligare uteslutningskriterier var intensifierat eller särskilt stöd i skolan, samt en neurologisk, neuropsykiatrisk, utvecklingsmässig eller psykiatrisk diagnos. Vidare uteslöts barn med okorrigerad syn- eller hörselskada, medicinering av psykologisk eller neurologisk orsak och prematurt födda barn.

Psykologer och forskningsassistenter utredde deltagarna med WISC-V. I samband med den kognitiva utredningen fyllde föräldrarna till de deltagande barnen i ett bakgrundsformulär om barnets språk- och daghemsbakgrund samt om eventuella sjukdomar och medicinering. I formuläret fanns även frågor om föräldrarnas modersmål och utbildningsnivå.

Sammanlagt var 165 barn lämpade att delta i denna studie. En enkät om barnens skolvitsord skickades ut till deras föräldrar. Av dessa svarade totalt 113 (68,5 %) föräldrar, men 4 av dem svarade för otydligt på frågorna om skolvitsord för att de skulle kunna beaktas i analyserna. Det slutliga samplet blev därmed 109 deltagare. I enkäten bads föräldrarna uppge de skolvitsord deras barn fått under våren 2020 i sex skolämnen. Enkäten var skapad i tre något olika versioner för att passa barn i olika åldersgrupper vad gäller skolämnen och typ av vitsord. Föräldrar till barn i årskurs 1–3 tillfrågades om barnets vitsord i modersmål, finska, engelska, matematik och omgivningslära/biologi. Utöver detta tillfrågades även föräldrar till barn i årskurs 4–7 och 9 om barnets vitsord i historia. För den yngsta gruppen, barn i årskurs 1–3, fick föräldrarna uppge skolvitsorden i text (verbal bedömning). För barn i årskurs 4–7 kunde föräldrarna uppge vitsorden antingen i siffror eller i text, och för barn i årskurs 9 enbart i siffror.

Mått

I denna studie mättes IQ med det kognitiva resursindexet (KRI) och arbetsminne med arbetsminnesindexet (AI) från den skandinaviska versionen av WISC-V. Skolresultat mättes med deltagarnas skolvitsord. AI mäter visuellt och auditivt arbetsminne. KRI ger ett mått på generell begåvning, men är mindre känsligt för inflytande från arbetsminneskapacitet och bearbetningshastighet än helskale-IK (HIK), eftersom deltesten som mäter arbetsminne inte ingår i KRI (Wechsler, 2014a). Resultatet i HIK utgör ett samlat mått på kognitiv funktionsnivå, där logiskt tänkande, förmåga till problemlösning, kunskapstillägnande, arbetsminne och bearbetningshastighet ingår (Wechsler, 2014a).

Verbala och numeriska betygsskalor

I de fall då föräldrarna uppgav sitt barns vitsord i verbal form ombads de att även skriva ut den fullständiga verbala skalan (exempelvis från lägst till högst vitsord). Flera olika verbala betygsskalor uppgavs, både gällande antalet nivåer och vad de olika nivåerna kallades. Alla föräldrar uppgav inte den verbala skalan. För att klargöra dessa olikheter kontaktades rektorerna i de involverade skolorna. De ombads beskriva antalet nivåer på den verbala betygsskalan de använde och vad de olika nivåerna kallades. Dessutom kontaktades Utbildningsstyrelsen i samma ärende. Med hjälp av svaren från rektorerna och Utbildningsstyrelsen skapades en sammanhängande verbal betygsskala med fem nivåer.

Den numeriska betygsskalan som används i Finland består av sju nivåer (4–10), vilket innebar att den verbala betygsskalan (bestående av fem nivåer) var tvungen att omstruktureras för att kunna slås ihop med den numeriska. Detta gjordes för att alla deltagare skulle kunna inkluderas i samma statistiska analyser. Den högsta nivån på den verbala betygsskalan (utmärkt), parades ihop med ett medelvärde av de numeriska vitsorden 9 och 10 och den mittersta nivån på den verbala skalan (tillfredsställande) parades ihop med ett medelvärde av

6 och 7. Då alla nivåer av verbal bedömning hade parats ihop med och omvandlats till ett siffervitsord, beräknades ett betygssnitt (varje deltagares medeltal av vitsorden hen fått).

Statistiska analyser

De statistiska analyserna gjordes i IBM SPSS Statistics version 27.0. Datavärden som saknades (exempelvis på grund av administrationsfel) imputerades. Innan analyserna gjordes, säkerställdes att alla nödvändiga antaganden uppfylldes. Demografiska data analyserades med oberoende t-test och chi-kvadrattest. Utöver detta utfördes en envägs oberoende variansanalys (ANOVA) för att undersöka om det fanns huvudeffekter av mammans eller pappans utbildningsnivå på betygsgenomsnitt, KRI eller AI. Bivariata korrelationer genomfördes mellan skolvitsord (betygsgenomsnitt och vitsord för de olika skolämnena separat) och KRI/AI.

Huvudanalysen utgjordes av en hierarkisk regressionsanalys. Prediktorvariablerna lades först in i en ordning (KRI följt av AI) och sedan i omvänd ordning (AI följt av KRI) för att undersöka variansen som den andra prediktorn tillförde utöver den första. Förutom den huvudsakliga regressionsanalysen genomfördes även två andra regressionsanalyser: en med barn i årskurs 2–5 (n = 48) och en med barn i årskurs 6–9 (n = 61). Dessa analyser utfördes för att undersöka om det fanns skillnader i den prediktiva styrkan hos KRI och AI hos yngre kontra äldre barn. I gruppen med yngre deltagare hade totalt 70,8 % fått ett verbalt vitsord i minst ett ämne. I gruppen med äldre deltagare hade totalt 9,8 % fått ett verbalt vitsord i minst ett ämne.

Resultat

Variansanalyserna visade att det inte fanns en signifikant huvudeffekt av mammans utbildningsnivå hos barnets KRI ($F(2;104) = 0{,}459$; $p = 0{,}633$), AI ($F(2;104) = 0{,}073$; $p = 0{,}929$) eller betygsgenomsnitt ($F(2;104) = 1{,}22$; $p = 0{,}299$). Det fanns inte heller någon signifikant huvudeffekt av pappans utbildningsnivå hos barnets KRI ($F(2;106) = 0{,}442$; $p = 0{,}644$), AI ($F(2;106) = 0{,}442$; $p = 0{,}644$) eller betygsgenomsnitt ($F(2;106) = 0{,}571$; $p = 0{,}567$).

Det fanns signifikanta positiva korrelationer mellan KRI och skolvitsorden i alla ämnen separat, såväl som med betygsgenomsnittet. Det fanns signifikanta positiva korrelationer mellan AI och matematik, modersmål, biologi, historia och betygssnittet.

Då KRI lades till före AI i den hierarkiska regressionsanalysen stod KRI för en signifikant del av variansen (24,8 %) i betygsgenomsnittet, medan den ytterligare variansen som AI stod för (0,8 %) inte var signifikant. Då däremot AI lades till först stod det för 11,3 %

av variansen, medan KRI stod för ytterligare 14,3 %. I denna modell bidrog både AI och KRI med en signifikant del av variansen. Med andra ord visade resultaten att variansen som AI stod för endast var signifikant då den lades till först i modellen. Utöver huvudanalysen utfördes även två andra hierarkiska regressionsanalyser: en med barn i årskurs 2–5 och en med barn i årskurs 6–9.

Barn i årskurs 2–5. När KRI lades till först, följt av AI, stod KRI för 24,8 % av variansen i betygsgenomsnittet och AI för ytterligare 0,2 % av variansen. KRI bidrog signifikant till variansen, vilket AI dock inte gjorde. När prediktorerna lades till i motsatt ordning stod AI för 6,2 % av variansen och KRI för ytterligare 18,8 %. Även här bidrog endast KRI signifikant till variansen.

Barn i årskurs 6–9. När KRI lades till först, följt av AI, stod KRI för 19,6 % av variansen i betygsgenomsnittet och AI för ytterligare 3 % av variansen. När prediktorerna lades till i motsatt ordning stod AI för 13,9 % av variansen i betygsgenomsnittet och KRI för ytterligare 8,7 %. I denna modell bidrog både AI och KRI signifikant till variansen.

Diskussion

Studiens syfte var att undersöka den prediktiva styrkan hos IQ och arbetsminne för skolresultat hos barn i skolåldern. Resultaten från tidigare studier med samma forskningsfråga pekar i olika riktningar. Resultaten i vissa studier tyder på att IQ har starkare prediktiv inverkan på skolresultat än vad arbetsminne har (Giofrè et al., 2017), medan andra studier tyder på det motsatta (Alloway & Alloway, 2010; Siquara et al., 2018).

I denna studie, i vilken IQ mättes med KRI, arbetsminne med AI och skolresultat med skolvitsord, tyder resultaten på att IQ är den av de två faktorerna som har starkast prediktiv inverkan på skolvitsord. Detta var fallet såväl för hela samplet som för de yngre (årskurs 2–5) respektive äldre (årskurs 6–9) barnen, vilket tyder på att effekten är densamma oberoende av ålder. Variansen som IQ bidrog med var signifikant oavsett om KRI lades till i den hierarkiska regressionsanalysen före eller efter AI. Den varians som arbetsminnet bidrog med var signifikant endast om AI lades till i analysen före KRI.

De tidigare studierna som undersökt den prediktiva styrkan hos IQ och arbetsminne för skolresultat har använt olika mått för samtliga variabler. Det här kan vara en bidragande orsak till att de tidigare studierna fått sinsemellan olika resultat. I denna studie användes KRI som mått på IQ, vilket kan ses som en styrka då det är ett tämligen omfattande mått bestående av fem deltest ur WISC-V. Jämfört med detta använde Alloway och Alloway (2010) och Siquara et al. (2018) endast ett fåtal deltest (1–3) som mått på IQ. Även något olika mått på arbetsminne användes i denna studie jämfört med tidigare studier. Den största skillnaden är dock troligtvis hur skolresultat har mätts. Tidigare studier har främst använt test som mäter kunskaper inom matematik och modersmål. I denna studie användes i stället ett betygssnitt baserat på sex skolämnen. Motivation kan påverka skolvitsord eftersom de sätts över en längre tid, jämfört med prestationstest som genomförs vid en viss tidpunkt (Sternberg et al., 2001). Detta kan vara en bidragande orsak till skillnader i resultaten mellan denna och tidigare studier. Till styrkorna i denna studie hör det relativt stora samplet och det faktum att skolvitsord i flera olika ämnen samlades in.

En del begränsningar i denna studie bör beaktas. Deltagarnas föräldrar hade inte alltid tillgång till barnens betyg, vilket ledde till att vissa svarade så gott de mindes gällande barnens vitsord trots att de uppgav att de var något osäkra på svaren. I denna studie användes dock ett betygssnitt, vilket innebär att påverkan av de osäkra svaren troligtvis inte har stor betydelse. En annan begränsning berör det faktum att olika system för verbal betygsättning användes i olika skolor. Därmed behövde vissa justeringar göras för att skapa en sammanhängande betygsskala. Slutligen är det viktigt att vid tolkningen av resultaten minnas att samplet i denna studie bestod av typiskt utvecklade barn utan inlärningssvårigheter. Därmed går det inte att utifrån dessa resultat uttala sig om den prediktiva styrkan hos IQ och arbetsminne för skolresultat i ett kliniskt sampel. Kliniker kan ha nytta av resultaten i denna studie då de väger betydelsen av IQ och arbetsminne mot varandra när det gäller hur ett barn klarar sig i skolan.

References

Aben, B., Stapert, S., & Blokland, A. (2012). About the Distinction between Working Memory and Short-Term Memory. *Frontiers In Psychology, 3*. https://doi.org/10.3389/fpsyg.2012.00301

Alloway, T., & Alloway, R. (2010). Investigating the predictive roles of working memory and IQ in academic attainment. *Journal Of Experimental Child Psychology, 106*(1), 20-29. https://doi.org/10.1016/j.jecp.2009.11.003

Alloway, T., Gathercole, S., Adams, A., Willis, C., Eaglen, R., & Lamont, E. (2005). Working memory and phonological awareness as predictors of progress towards early learning goals at school entry. *British Journal Of Developmental Psychology, 23*(3), 417-426. https://doi.org/10.1348/026151005X26804

Alloway, T., Gathercole, S., & Pickering, S. (2006). Verbal and Visuospatial Short-Term and Working Memory in Children: Are They Separable?. *Child Development, 77*(6), 1698-1716. https://doi.org/10.1111/j.1467-8624.2006.00968.x

Alloway, T., Gathercole, S., Willis, C., & Adams, A. (2004). A structural analysis of working memory and related cognitive skills in young children. *Journal Of Experimental Child Psychology, 87*(2), 85-106. https://doi.org/10.1016/j.jecp.2003.10.002

Alloway, T., & Passolunghi, M. (2011). The relationship between working memory, IQ, and mathematical skills in children. *Learning And Individual Differences, 21*(1), 133-137. https://doi.org/10.1016/j.lindif.2010.09.013

American Psychological Association. (n.d.). Intelligence. In APA Dictionary of Psychology. Retrieved April 5, 2022 from https://dictionary.apa.org/intelligence

Baddeley, A. (2000). The episodic buffer: a new component of working memory?. *Trends In Cognitive Sciences, 4*(11), 417-423. https://doi.org/10.1016/S1364-6613(00)01538-2

Baddeley, A. D., & Hitch, G. (1974). Working memory. *Psychology of Learning And Motivation, 8*, 47–89 https://doi.org/10.1016/S00797421(08)60452-1

Borella, E., & de Ribaupierre, A. (2014). The role of working memory, inhibition, and processing speed in text comprehension in children. *Learning And Individual Differences, 34,* 86-92. https://doi.org/10.1016/j.lindif.2014.05.001

Bull, R., Espy, K., & Wiebe, S. (2008). Short-Term Memory, Working Memory, and Executive Functioning in Preschoolers: Longitudinal Predictors of Mathematical Achievement at Age 7 Years. *Developmental Neuropsychology, 33*(3), 205-228. https://doi.org/10.1080/87565640801982312

Bull, R., & Scerif, G. (2001). Executive Functioning as a Predictor of Children's Mathematics Ability: Inhibition, Switching, and Working Memory. *Developmental Neuropsychology, 19*(3), 273-293. https://doi.org/10.1207/S15326942DN1903_3

Caemmerer, J., Maddocks, D., Keith, T., & Reynolds, M. (2018). Effects of cognitive abilities on child and youth academic achievement: Evidence from the WISC-V and WIAT-III. *Intelligence, 68,* 6-20. https://doi.org/10.1016/j.intell.2018.02.005

Cain, K., Oakhill, J., & Bryant, P. (2004). Children's Reading Comprehension Ability: Concurrent Prediction by Working Memory, Verbal Ability, and Component Skills. *Journal Of Educational Psychology, 96*(1), 31-42. https://doi.org/10.1037/0022-0663.96.1.31

Caviola, S., Mammarella, I., Cornoldi, C., & Lucangeli, D. (2012). The involvement of working memory in children's exact and approximate mental addition. *Journal Of Experimental Child Psychology, 112*(2), 141-160. https://doi.org/10.1016/j.jecp.2012.02.005

Chiesi, F., & Primi, C. (2010). Cognitive and non-cognitive factors related to students' statistics achievement. *Statistics education research journal, 9*(1), 6-26. https://doi.org/10.52041/serj.v9i1.385

Cowan, N. (2008). Chapter 20 What are the differences between long-term, short-term, and working memory?. *Progress In Brain Research*, 323-338. https://doi.org/10.1016/S0079-6123(07)00020-9

Cowan, N., & Alloway, T. P. (2008). The development of working memory. In N. Cowan (Ed.), *Development of memory in childhood* (2nd ed., pp. 303–342). Hove, UK: Psychology Press.

Daneman, M., & Merikle, P. (1996). Working memory and language comprehension: A meta-analysis. *Psychonomic Bulletin & Review, 3*(4), 422-433. https://doi.org/10.3758/BF03214546

Deary, I., Strand, S., Smith, P., & Fernandes, C. (2007). Intelligence and educational achievement. *Intelligence, 35*(1), 13-21. https://doi.org/10.1016/j.intell.2006.02.001

Duckworth, A., & Seligman, M. (2005). Self-Discipline Outdoes IQ in Predicting Academic Performance of Adolescents. *Psychological Science, 16*(12), 939-944. https://doi.org/10.1111/j.1467-9280.2005.01641.x

Engel, P., Santos, F., & Gathercole, S. (2008). Are Working Memory Measures Free of Socioeconomic Influence?. *Journal Of Speech, Language, And Hearing Research, 51*(6), 1580-1587. https://doi.org/10.1044/1092-4388(2008/07-0210)

Field, A. (2013). *Discovering statistics using IBM SPSS statistics: and sex and drugs and rock 'n' roll* (4th ed.). SAGE Publications.

The Finnish National Agency for Education. (2020a). *Grunderna för läroplanen för den grundläggande utbildningen.* Retrieved 3 February 2022, from https://www.oph.fi/sites/default/files/documents/bedomning-i-den-grundlaggande-utbildningen.10.2.2020_0.pdf

The Finnish National Agency for Education. (2020b). *Bedömningen i den grundläggande utbildningen förenhetligas.* Retrieved 16 August 2022, from https://www.oph.fi/sites/default/files/documents/bakgrundsinfopaket-for-medierna.pdf

Gathercole, S., Alloway, T., Willis, C., & Adams, A. (2006a). Working memory in children with reading disabilities. *Journal Of Experimental Child Psychology, 93*(3), 265-281. https://doi.org/10.1016/j.jecp.2005.08.003

Gathercole, S., Lamont, E., & Alloway, T. (2006b). Working Memory in the Classroom. *Working Memory And Education*, 219-240. https://doi.org/10.1016/B978-012554465-8/50010-7

Gibbons, A., & Warne, R. (2019). First publication of subtests in the Stanford-Binet 5, WAIS-IV, WISC-V, and WPPSI-IV. *Intelligence, 75*, 9-18. https://doi.org/10.1016/j.intell.2019.02.005

Giofrè, D., Borella, E., & Mammarella, I. (2017). The relationship between intelligence, working memory, academic self-esteem, and academic achievement. *Journal Of Cognitive Psychology, 29*(6), 731-747. https://doi.org/10.1080/20445911.2017.1310110

Giofrè, D., Mammarella, I., & Cornoldi, C. (2014). The relationship among geometry, working memory, and intelligence in children. *Journal Of Experimental Child Psychology, 123,* 112-128. https://doi.org/10.1016/j.jecp.2014.01.002

Holmes, J., & Adams, J. (2006). Working Memory and Children's Mathematical Skills: Implications for mathematical development and mathematics curricula. *Educational Psychology, 26*(3), 339-366. https://doi.org/10.1080/01443410500341056

Kane, M., Brown, L., McVay, J., Silvia, P., Myin-Germeys, I., & Kwapil, T. (2007). For Whom the Mind Wanders, and When. *Psychological Science, 18*(7), 614-621. https://doi.org/10.1111/j.1467-9280.2007.01948.x

Kutsyuruba, B., Klinger, D., & Hussain, A. (2015). Relationships among school climate, school safety, and student achievement and well-being: a review of the literature. *Review Of Education, 3*(2), 103-135. https://doi.org/10.1002/rev3.3043

Nation, K., Adams, J., Bowyer-Crane, C., & Snowling, M. (1999). Working Memory Deficits in Poor Comprehenders Reflect Underlying Language Impairments. *Journal Of Experimental Child Psychology, 73*(2), 139-158. https://doi.org/10.1006/jecp.1999.2498

Raghubar, K., Barnes, M., & Hecht, S. (2010). Working memory and mathematics: A review of developmental, individual difference, and cognitive approaches. *Learning And Individual Differences, 20*(2), 110-122. https://doi.org/10.1016/j.lindif.2009.10.005

Roth, B., Becker, N., Romeyke, S., Schäfer, S., Domnick, F., & Spinath, F. (2015). Intelligence and school grades: A meta-analysis. *Intelligence, 53*, 118-137. https://doi.org/10.1016/j.intell.2015.09.002

Saarela, J. (2021). Finlandssvenskarna 2021- En statistisk rapport. *Svenska Finlands Folkting* (pp. 55-56). Retrieved 17 August 2022, from https://folktinget.fi/Site/Data/1597/Files/Finlandssvenskarna%202021_statistisk%20rapport_Folktinget_KLAR.pdf

Sirin, S. (2005). Socioeconomic Status and Academic Achievement: A Meta-Analytic Review of Research. *Review Of Educational Research, 75*(3), 417-453. https://doi.org/10.3102/00346543075003417

Siquara, G., Lima, C., & Abreu, N. (2018). Working memory and intelligence quotient: Which best predicts on school achievement?. *Psico, 49*(4), 365. doi: https://doi.org/10.15448/1980-8623.2018.4.27943

Sternberg, R., Grigorenko, E., & Bundy, D. (2001). The Predictive Value of IQ. *Merrill-Palmer Quarterly, 47*(1), 1-41. https://doi.org/10.1353/mpq.2001.0005

Stothard, S., & Hulme, C. (1992). Reading comprehension difficulties in children. *Reading And Writing, 4*(3), 245-256. https://doi.org/10.1007/BF01027150

Swanson, H., & Beebe-Frankenberger, M. (2004). The Relationship Between Working Memory and Mathematical Problem Solving in Children at Risk and Not at Risk for Serious Math Difficulties. *Journal Of Educational Psychology, 96*(3), 471-491. https://doi.org/10.1037/0022-0663.96.3.471

Swanson, H., & Sachse-Lee, C. (2001). Mathematical Problem Solving and Working Memory in Children with Learning Disabilities: Both Executive and Phonological Processes Are Important. *Journal Of Experimental Child Psychology, 79*(3), 294-321. https://doi.org/10.1006/jecp.2000.2587

Unsworth, N., & Engle, R. (2007). On the division of short-term and working memory: An examination of simple and complex span and their relation to higher order abilities. *Psychological Bulletin, 133*(6), 1038-1066. https://doi.org/10.1037/0033-2909.133.6.1038

Weber, H., Lu, L., Shi, J., & Spinath, F. (2013). The roles of cognitive and motivational predictors in explaining school achievement in elementary school. *Learning And Individual Differences, 25,* 85-92. https://doi.org/10.1016/j.lindif.2013.03.008

Wechsler, D. (1992). *Wechsler intelligence scale for children - Third edition*. London: Psychological Corporation.

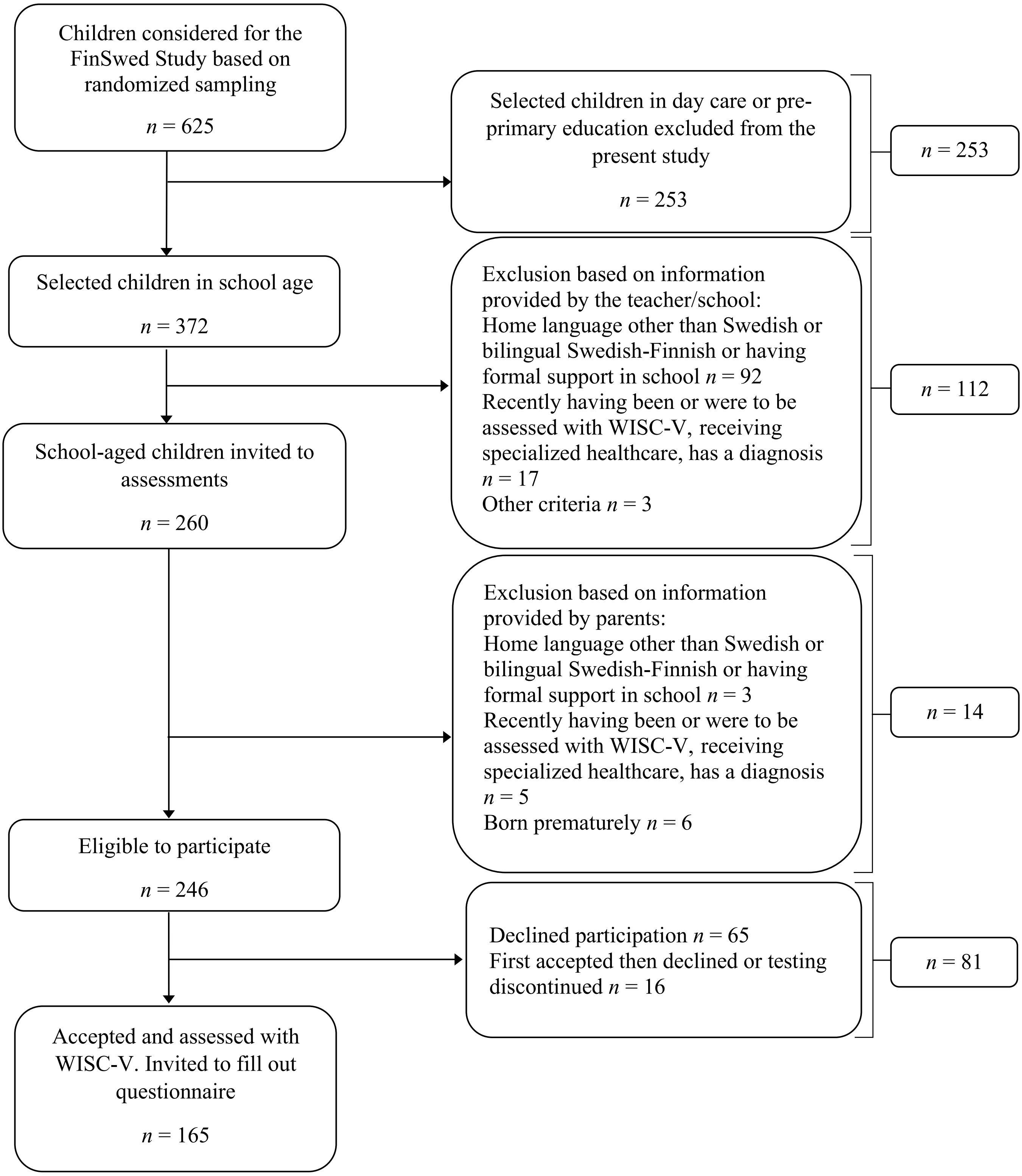
Wechsler, D. (2014a). *Wechsler intelligence scale for children - Fifth edition. (Swedish translation ed.)*. NCS Pearson, Incorporated.

Wechsler, D. (2014b). *WISC-V: Technical and interpretive manual*. NCS Pearson, Incorporated.

Willcutt, E., Doyle, A., Nigg, J., Faraone, S., & Pennington, B. (2005). Validity of the Executive Function Theory of Attention-Deficit/Hyperactivity Disorder: A Meta-Analytic Review. *Biological Psychiatry, 57*(11), 1336-1346. https://doi.org/10.1016/j.biopsych.2005.02.006

Appendix 1

Flowchart of the Sample Selection in the FinSwed Study



Note. The participants who were accepted but chose to decline refers to those who withdrew from participation, for example due to the COVID-19 pandemic.

PRESSMEDDELANDE

Hos finlandssvenska skolelever visade sig intelligens ha större inverkan på skolvitsord jämfört med arbetsminne

Pro gradu-avhandling i psykologi

Fakulteten för humaniora, psykologi och teologi, Åbo Akademi

Resultatet från en pro gradu-avhandling vid Åbo Akademi tyder på att intelligens har större inverkan på skolvistord, jämfört med arbetsminne. Studien undersökte det prediktiva värdet hos intelligens (IQ) och arbetsminne för skolvitsord hos finlandssvenska skolelever. I studien deltog sammanlagt 109 barn i åldern 7–16 år. Deltagarna utreddes med den svenska versionen av WISC-V. Därtill samlades deltagarnas skolvitsord i sex ämnen (modersmål, finska, engelska, matematik, biologi och historia) in med hjälp av deras föräldrar. I föreliggande studie mättes intelligens och arbetsminne med det kognitiva resursindexet respektive arbetsminnesindexet ur WISC-V. Skolresultat mättes med ett medeltal av deltagarnas skolvitsord. Resultaten indikerar att intelligens har en starkare prediktiv styrka på skolresultat jämfört med arbetsminne. Detta var fallet för såväl hela samplet, liksom för de yngre och äldre deltagarna (barn i årskurs 2–5 respektive 6–9). Intelligens och arbetsminne stod tillsammans för en fjärdedel av variansen i skolresultaten, vilket tyder på att det också finns flera andra faktorer att ta hänsyn till.

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